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# CARTEL DAMAGES CLAIMS AND THE PASSING-ON DEFENSE*

FRANK VERBOVEN†
THEON VAN DIJK‡

We develop a general framework for computing cartel damages claims. We decompose a direct purchaser plaintiff's lost profits in three parts: the price overcharge, the pass-on effect and the output effect. The output effect is usually neglected: it is the lost business resulting from passing on the price overcharge. To evaluate the relative importance of the three effects, we introduce various models of imperfect competition for the plaintiff's industry. We show that the passing-on defense generally remains justified after accounting for the output effect, provided that the cartel affects a sufficient number of firms. We derive exact discounts to the price overcharge, and illustrate how to compute these in the European vitamin cartel. We finally extend our framework to measure the cartel's total harm, i.e., the total damages to direct purchasers and their consumers.

## I. INTRODUCTION

THE ANTICOMPETITIVE PRICE OVERCHARGE HAS BEEN COMMONLY USED as a basis for computing damages claims in price-fixing cartels. There is, however, an ongoing debate as to whether the cartel members may resort to a passing-on defense. Such a defense entails the argument that the purchaser plaintiff may have passed on part of the cartel's price overcharge to its own customers and correspondingly suffered lower losses than the overcharge. In both the U.S. and Europe there has recently been a renewed interest in properly assessing cartel damages, including the possible consideration of the passing-on defense.[1]

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†Authors' affiliations: Catholic University of Leuven and Grensstraat 81, 1970 Brussels, Belgium and C.E.P.R. Naamsestraat 69, 3000 Leuven, Belgium
*e-mail*: *Frank.Verboven@econ.kuleuven.be*
‡Lexonomics, Grensstraat 81, 1970 Brussels, Belgium.
*e-mail*: *t.vandijk@lexonomics.com*

[1] The U.S. Antitrust Modernization Commission [2007] has recently recommended making cartel damages claims in line with lost profits, implying the possibility of a passing-on defense (although there was no consensus on this recommendation, see Commissioner Dennis Carlton [2007]). The European Commission [2005] issued a Green Paper on private cartel damages and

Against this background we develop a general economic framework for computing cartel damages. We focus on a direct purchaser plaintiff's lost profits, but we also apply our approach to consider the cartel's total harm (the sum of damages to direct purchasers and their consumers). We decompose the direct purchaser plaintiff's lost profits from the cartel into three effects. First, the price overcharge or cost effect is the extra price the plaintiff has to pay for the cartelized input. Second, the pass-on effect reflects the extent to which the purchaser plaintiff can shift the burden of the price overcharge to its own customers. Third, the usually neglected output effect refers to the sales that are lost when part of the price overcharge is passed on to the customers.

We then introduce various models of imperfect competition to describe the downstream industry in which the purchaser plaintiff operates. This enables us to evaluate the relative importance of the three effects from the cartel. Consistent with common practice, we take the price overcharge (or cost effect) as the basis for computing damages and show how to compute a discount to this overcharge. This discount captures the pass-on effect, but suitably adjusted for the output effect. We first consider the case of a common cost increase, in which all competitors in the plaintiff's industry are affected by the cartel. We show that in this case the discount to the price overcharge is generally positive, unless the plaintiff operates itself in a fully cartelized downstream industry. This motivates an adjusted passing-on defense, where the adjustment factor reflects the output effect and depends on the intensity of competition, as illustrated for Bertrand or Cournot industries.

We next consider the case of a firm-specific cost increase, in which not necessarily all of the plaintiff's competitors are affected by the cartel. This is relevant in several circumstances, for example when some of the cartel members are vertically integrated and do not overcharge their own downstream units. In this case the output effect becomes more important, because the plaintiff may now also lose business to its unaffected competitors within the industry, in addition to losing business outside the industry. We show that an adjusted passing-on defense remains economically justified in a Bertrand industry. In a Cournot industry, however, the passing-on defense becomes invalid if there are sufficiently many unaffected competitors, since these respond expansively to the output contractions of the plaintiff and other affected firms. For both the Bertrand and the Cournot models, we derive exact discounts to the price overcharge when the adjusted passing-on defense is justified. These discounts are easy to interpret and depend on observable variables for the plaintiff's industry, such as the

the possibility of a passing-on defense. We review these developments against the history of previous case law in section 2.

pass-on rate, the total number of firms, the number of firms affected by the cartel, the plaintiff's and/or the other firms' market shares.

To illustrate our results, we apply an adjusted passing-on defense to the European vitamin cartel of 1989–1999. We show how to compute discounts to the price overcharge that is based on information from the public domain. In particular, we require the following information for the plaintiff's downstream industry: the total number of firms, the number of firms affected by the cartel and the market shares of the plaintiffs and their competitors. In this application we find that the price overcharge should be discounted by a quite large amount, even after adjusting for the output effect.

Most previous research has focused on the law and economics of the passing-on defense, providing informational and incentive arguments for or against the use of a passing-on defense in cartel damages cases.[2] We instead focus on measuring the economic effects and stress the essential importance of the output effect whenever the passing-on defense is considered. To our knowledge there are only a few papers that explicitly elaborate on the output effect (or 'lost business' effect), i.e., Kosicki and Cahill [2006] and Hellwig [2006]. These papers focus on the case in which the plaintiff's industry is itself fully cartelized (so that the passing-on defense becomes invalid), or consider some other special cases with graphical or numerical analysis. In contrast, we identify the role of the output effect in a wide variety of oligopoly industries, and account for the possibility that some of the plaintiff's competitors are not affected by the cartel. Furthermore, we pin down the precise informational requirements in implementing an adjusted passing-on defense: in addition to estimating the degree of pass-on as in a traditional passing-on defense, one essentially also needs to measure the extent of market power in the plaintiff's downstream industry.

We obtain these results based on a simple differential approach, which looks at the effects of a 'small' price overcharge. This approach has the advantage of clarifying the economic role of the output effect in a general framework. It ignores, however, second-order effects which may become important for large price overcharges. To assess the effects of large overcharges one could apply 'simulation analysis,' as is done in other areas of antitrust such as merger analysis (e.g., Werden and Froeb [1994]).

Our analysis largely focuses on the cartel damages to a direct purchaser plaintiff. Basso and Ross [2007] instead consider the cartel's total harm, i.e.,

[2] Landes and Posner [1979] advance several arguments as to why damages claims by direct purchasers without a passing-on defence are more reliable and hence have a better deterrence effect. Harris and Sullivan [1979], in contrast, argue in favour of the passing-on defense to ensure a correct damages compensation. In an interesting recent paper Schinkel *et al.* [2008] show how the cartel may have an incentive to 'bribe' direct purchasers not to bring damages claims if indirect purchasers cannot bring damages claims. See van Dijk and Verboven (2007) for a more detailed overview of these arguments.

the total effect on the direct purchasers and on the final purchasers. Boone and Müller [2008] look at the question of how the cartel's total harm is distributed between direct purchasers and consumers. Han, Schinkel and Tuinstra [2008] focus on the role of many downstream and upstream firms along the production chain. Inspired by these papers, we briefly extend our differential approach to assess the cartel's total harm. The pass-on effect is then only a transfer between the direct purchasers and final consumers. We show that the cartel's total harm therefore unambiguously exceeds the price overcharge by an amount equal to the output effect.[3] Hence, an adjusted passing-on defense against a purchaser plaintiff may actually turn against the defendant, since the evidence required to adjust the pass-on effect for the output effect may also be used to demonstrate by how much the cartel's total harm exceeds the price overcharge.

The paper is organized as follows. Section 2 reviews previous practices towards cartel damages claims and the passing-on defense. Section 3 presents the general economic framework, decomposing the plaintiff's lost profits in a cost, pass-on and output effect. Section 4 considers the case of a common cost increase (to all of the plaintiff's competitors), and section 5 the case of a firm-specific cost increase (to a subset of the plaintiff's competitors). Section 6 provides an application to the European vitamin cartel. Section 7 considers the cartel's total harm and section 8 concludes.

## II. STATE OF PLAY IN THE U.S. AND EUROPE

We briefly review the history and logic of cartel damages claims, with a focus on the passing-on defense. For a more detailed discussion, we refer to the references in this section, and the extensive literature they cite.

### *United States*

The current situation in the U.S. is the result of three major Supreme Court decisions, *Hanover Shoe*, *Illinois Brick*, and *ARC America*, and subsequent legislation by various states.[4] In *Hanover Shoe*, the defendant argued that the overcharged purchaser plaintiff does not suffer losses if the price overcharge is imposed equally on all of the purchaser's competitors and if the demand is so inelastic that the purchasers can pass on the overcharge without suffering a decline in sales. The Supreme Court rejected this argument on the grounds of insurmountable practical difficulties in proving

[3] This corresponds to Basso and Ross' [2007] result that the total harm is higher than the price overcharge. However, they do not relate this to the output effect, which emerges clearly from our framework and which suggests how to measure it practically in terms of observable variables.

[4] The three cases are Hanover Shoe Inc. v. United Shoe Machinery Corp., 392 U.S. 481 [1968] and Illinois Brick Co. v. Illinois, 431 U.S. 720 [1977], and California v. ARC America Corp., 490 U.S. 93 [1989].

that the purchaser indeed passed on the price overcharge and how this passing-on would affect sales. Furthermore, it considered that the indirect purchasers tend to be too dispersed and too weak to subsequently recover any damages resulting from the passing-on by the direct purchasers, implying that the cartel offenders might get off too lightly. In *Illinois Brick* the Court continued this logic and denied indirect purchasers the right to claim damages, since the *Hanover Shoe* decision already made the cartel liable for the full damages to direct purchasers.

Interestingly, Justice White, who delivered the opinion of the Court in *Illinois Brick*, points at two complicating factors in practice that are assumed away in 'the economist's hypothetical model' (original wording from the *Hanover Shoe* decision): 'Overcharged direct purchasers often sell in imperfectly competitive markets. They often compete with other sellers that have not been subject to the overcharge . . .' (see *http://www.ripon.edu/Faculty/bowenj/antitrust/ilbrvill.htm*). Our paper deals with precisely these two factors: section 4 focuses on imperfect competition, and section 5 adds complications relating to the fact that not all competitors may be subject to the overcharge.

There was considerable opposition against *Illinois Brick* in the decade following the decision. Congress was not able to pass any bills to overturn the decision, but in *ARC America*, the Supreme Court legitimized indirect purchaser suits in state courts. Furthermore, various states have passed *Illinois Brick* repealer laws or used existing consumer protection statutes to permit indirect purchasers to bring damages claims against cartels; see Hussain, Garrett and Howell [2001]. As discussed in Kosicki and Cahill [2006] several of these states also entitled the defendant to resort to a passing-on defense against these indirect purchasers.

Under the current situation, direct purchasers can thus in principle claim the full price overcharge in federal courts (whether or not passed on). Furthermore, the indirect purchasers may obtain a duplicate part of that amount, i.e., their own lost profits, in some state courts. While there do not appear to be cases in which this has lead to an overcompensation of all parties affected by the cartel, the Antitrust Modernization Commission [2007] has recently recommended making direct and indirect purchaser damages claims more in line with their actual lost profits from the cartel. Following these recommendations would open the door for a passing-on defense, not just against the indirect but also against the direct purchasers of a cartel.

*Europe*

In Europe the experience with private damages claims in competition law infringement cases has been rather limited. There is, however, extensive case law in other areas, for example in cases where undertakings claim restitution of illegal duties and levies from the state. As discussed in Norberg [2005], in *Comateb* the European Court of Justice accepted that a passing-on defense

was compatible with Community Law, but also clarified that the plaintiff 'may have suffered damage as a result of the very fact that he passed on the charge . . . because the increase in price has led to a decrease in sales.'[5] This appears closely related to the output effect we emphasize in our analysis below.

Only recently, in *Courage* the European Court of Justice confirmed that infringements of Articles 81 and 82 of the EC Treaty provide a legal basis for bringing damages claims.[6] Following this decision, the European Commission put private cartel damages claims and the possible consideration of a passing-on defense as a high priority on the agenda. It requested the Ashurst study on private enforcement of competition policy in 2004.[7] This lead to the European Commission's [2005] Green Paper on damages actions for breach of antitrust rules, which includes a discussion on the role of the passing-on defense. Interestingly, the Commission writes: 'It can be said that there is no passing on defense in Community law; rather, there is an unjust enrichment defense which requires (1) proof of passing on . . . and (2) proof of no reduction in sales or other reduction to income' (European Commission [2005], p. 48). One may interpret this unjust enrichment defense as an adjusted version of the passing-on defense, which also accounts for the additional output effect following pass-on.[8] Our own analysis will show how to implement such an adjusted passing-on defense in a wide variety of competitive circumstances.

## III. GENERAL ECONOMIC FRAMEWORK

This section decomposes the purchaser plaintiff's lost profits from the cartel into three effects: the price overcharge (or cost effect), the pass-on effect and the output effect. Our only assumptions at this point are that the plaintiff takes its input prices as given, including the price of the input purchased from the cartel, and chooses its input mix to minimize its total costs. We do not yet make specific assumptions as to the nature of competition in the plaintiff's industry.

Consider a plaintiff firm selling $q$ units of total output at a price $p$. The plaintiff chooses its inputs to minimize its total costs, subject to a standard production function technology. One of its inputs is the cartelized input, of which it purchases $x$ units at an input price $w$. Write the plaintiff's cost

[5] Joined cases C-192/95 to C-218/95 *Société Comateb*, 1997 ECR I 165, CJ (http://europa.eu.int/eur-lex/lex/LexUriServ/LexUriServ.do?uri=CELEX:61995J0192:EN:HTML).

[6] C-453/99 Courage v. Crehan 2001 ECR I-6297 CJ.

[7] The legal part of the Ashurst study was written by Waelbroeck, Slater and Even-Shoshan [2004].

[8] Very recently, the European Commission [2008] published a White Paper, in which it recommends that all affected parties have legal standing to claim damages and where it allows for the possibility of a passing-on defense.

function $C(w, q)$ as a function of $w$ and $q$, and omit the other input prices as arguments. The plaintiff's profits $\pi$ are simply total revenues minus total costs:

$$\pi = pq - C(w, q).$$

We assume that the formation of the cartel leads to an increase in the input price $w$. The corresponding price overcharge is defined as the cartel input price $w_1$ minus the but-for input price $w_0$ (i.e., the input price as it would have been without the cartel). We will follow a differential approach and consider the effects on the plaintiff's profits of a 'small cartel,' i.e., a small price overcharge d$w$. This is similar to Farrell and Shapiro's [1990] approach of looking at the effects of an 'infinitesimal merger.' It has the advantage of highlighting in a simple way the key channels through which the cartel affects the plaintiff's profits. It ignores however second-order effects which may become potentially important for large price overcharges $w_1 - w_0 = \int_{w_0}^{w_1} \mathrm{dw}$.[9] The change in the plaintiff's profits due to a small cartel or small price overcharge d$w$ is:

$$\mathrm{d}\pi = -\frac{\partial C(w,q)}{\partial w}\mathrm{d}w + q\mathrm{d}p + \left(p - \frac{\partial C(w,q)}{\partial q}\right)\mathrm{d}q.$$

According to Shepard's Lemma, the plaintiff's demand for the cartelized input is $x = \frac{\partial C(w,q)}{\partial w}$, so that

$$(1) \qquad \mathrm{d}\pi = -x\mathrm{d}w + q\mathrm{d}p + \left(p - \frac{\partial C(w,q)}{\partial q}\right)\mathrm{d}q.$$

Equation (1) shows that the change in the plaintiff's profits due to the cartel can be decomposed into three components.

*Price overcharge or cost effect*. This effect ($-x\mathrm{d}w$) is the input price increase d$w$, multiplied by the total inputs $x$ purchased from the cartel. This effect on profits is obviously negative.

*Pass-on effect*. This effect ($q\mathrm{d}p$) is the increase in revenue that follows if the plaintiff passes part of the input price increase on to its customers in the form of a higher output price d$p$. The pass-on is typically positive ($\mathrm{d}p > 0$), thus counteracting at least part the direct damages from the price overcharge d$w$.

[9] One such effect arises from distortionary input substitution away from the cartelized input. The size of the price overcharge and the implied second-order effects is an empirical question, and typically varies widely; see e.g., Connor [2004] and Levenstein and Suslow [2006]. Extending our framework to allow for large price overcharges would entail integrating over the small overcharges d$c$. This does not give general closed form solutions, but simulation analysis based on specific functional form assumptions (as in merger analysis) would provide a solution.

*Output effect*. This effect $\left(p - \frac{\partial C(w,q)}{\partial q}\right)\mathrm{d}q$ refers to the lost profits associated with any lost sales $\mathrm{d}q$ following the higher output price set by the plaintiff. This effect is typically negative ($\mathrm{d}q < 0$), especially if the plaintiff earns a high profit margin $p - \frac{\partial C(w,q)}{\partial q}$, as in imperfectly competitive markets. The output effect can only be ignored if the plaintiff is active in a perfectly competitive market, since then $p = \frac{\partial C(w,q)}{\partial q}$.

The price overcharge or cost effect forms the basis for the plaintiff's cartel damages claims in both the U.S. and Europe. The defendant may subsequently attempt to resort to the pass-on effect to obtain a discount from the price overcharge, at least if this has a legal basis in the jurisdiction. However, our framework shows that the pass-on effect also implies an output effect. Hence, if a passing-on defense is allowed the output effect should also be incorporated.

While our framework stresses the role of three key effects from the cartel in general terms, it does not say anything about their relative magnitudes. In the next sections, we shall introduce additional structure on the competitive conditions in the plaintiff's downstream market to quantify the relative importance of the three effects. For example, if the plaintiff behaves as a monopolist, the pass-on and output effects cancel out from the monopolist's first-order condition. More generally, we identify conditions under which the pass-on effect dominates the output effect. This motivates an adjusted passing-on defense in the form of easy-to-interpret discounts to the cost effect. We begin with the simpler case of a common cost increase, where all firms in the plaintiff's downstream market are symmetrically affected by the price overcharge $\mathrm{d}w$, and subsequently move to the more complicated setting in which some of the plaintiff's rivals are not affected.

*Constant Returns to Scale*. To simplify the exposition, the rest of the paper assumes that the plaintiff has a constant returns to scale cost function, $C(w,q) = c(w)q = cq$.[10] This implies that marginal cost is independent of output, $\frac{\partial C(w,q)}{\partial q} = c(w) = c$, and that input demand is proportional to total output, $x = \frac{\partial C(w,q)}{\partial w} = c'(w)q$. Furthermore, $\mathrm{d}c = c'(w)\mathrm{d}w = \frac{x}{q}\mathrm{d}w$. The change in the plaintiff's profits, given by (1), then simplifies to:

$$(2) \qquad \mathrm{d}\pi = -q\mathrm{d}c + q\mathrm{d}p + (p-c)\mathrm{d}q.$$

Equation (2) expresses the cartel's price overcharge in terms of the overall marginal cost increase, $\mathrm{d}c$, instead of the input price increase, $\mathrm{d}w$. We will follow this practice in the rest of the paper. To reinterpret our results in terms of the input price increase $\mathrm{d}w$, simply substitute $\mathrm{d}c = \frac{x}{q}\mathrm{d}w$.

[10] The assumption of constant marginal cost is not without consequences. If marginal cost were increasing in output, the extent of pass-on could be expected to be smaller, which would also result in a lower output effect. The reverse is true if marginal cost is decreasing in output.

## IV. COMMON COST INCREASE

We begin with the situation in which the cartel affects all firms in the plaintiff's industry. More specifically, assume that all firms have the same (constant) marginal cost $c$ prior to the cartel and are subject to a common marginal cost increase d$c$ due to the cartel. Let the plaintiff's demand when all firms set the same price $p$ be $q = H(p)$. This is the traditional Chamberlinian $DD$ curve. Assume this is a constant fraction $\alpha$ of total industry demand when all firms set the same price, i.e., $H(p) = \alpha Q(p)$.[11] The industry-level price elasticity of demand is then given by $\varepsilon = -\frac{\partial Q(p)}{\partial p} / \frac{p}{Q(p)} = -\frac{\partial H(p)}{\partial p} / \frac{p}{H(p)}$. Assume that the cost, demand and competitive conditions generate a symmetric equilibrium, i.e., an equilibrium in which all firms sell their output at the same price $p$. Denote the equilibrium price as a function of the common marginal cost by $p = p^*(c)$. Assume this function is increasing in $c$, and define the industry-level pass-on rate by $\tau = \frac{\partial p^*(c)}{\partial c} > 0$. While this set-up imposes much symmetry, it allows for various sources of market power in the plaintiff's market: product differentiation, the number of competitors, and the competitive conduct (e.g., Bertrand versus Cournot). This will be illustrated with specific models below.

The plaintiff's equilibrium profits as a function of the common marginal cost are:

$$\pi(c) = (p^*(c) - c)H(p^*(c)).$$

The change in its profits due to the cartel, given in general by (2), is therefore:

$$\text{(3)} \qquad \mathrm{d}\pi = \left(-q + q\frac{\partial p^*(c)}{\partial c} + (p - c)\frac{\partial H(p)}{\partial p}\frac{\partial p^*(c)}{\partial c}\right)\mathrm{d}c.$$

This confirms that the cartel has three effects: a price overcharge or cost effect (first term), and the pass-on and output effects (second and third terms). But the additional structure on the plaintiff's downstream market now enables us to quantify the relative importance of these three effects in terms of familiar economic concepts. To see this, define

$$\text{(4)} \qquad \lambda = \frac{p - c}{p}\varepsilon$$

as the competition intensity parameter for the plaintiff's industry, as in Corts [1999]. This is a number between zero and one, measuring the plaintiff's actual markup $\frac{p-c}{p}$ relative to the maximum markup it could achieve as a monopolist or as a member of a downstream cartel $\left(\frac{1}{\varepsilon}\right)$. Substituting the

[11] The assumption of a constant fraction generalizes the usual full symmetry assumption that firms obtain the same fraction of industry demand.

definitions of $\varepsilon$, $\tau$ and $\lambda$ in (3) and rearranging, we can write the change in the plaintiff's profit due to the cartel as:

$$\text{(5)} \qquad d\pi = -(1-(1-\lambda)\tau)q\,dc.$$

Equation (5) says that the price overcharge or cost effect of the cartel ($-q\,dc$) forms a starting basis for computing cartel damages, but that a discount equal to $(1-\lambda)\tau$ should be applied. Since $\tau > 0$ and $\lambda$ is between zero and one, this discount is positive or zero, but less than the pass-on rate. We therefore have:

*Proposition 1*. Consider a symmetric industry with a common cost increase due to the cartel. The appropriate discount to the price overcharge suffered by the plaintiff is weakly positive, and is given by:

$$\text{(6)} \qquad \text{discount} = (1-\lambda)\tau \geqslant 0.$$

An adjusted passing-on defense is therefore justified, unless the plaintiff's downstream industry is itself fully cartelized ($\lambda = 1$).[12]

The downward adjustment of the pass-on rate in computing the discount stems from the fact that pass-on may lead to a further output effect. In a perfectly competitive industry ($\lambda = 0$), the output effect is absent since lost sales do not matter at the margin (since markups are zero). The discount to the overcharge is then simply the unadjusted pass-on rate. But as the plaintiff's industry becomes less competitive ($\lambda > 0$), the lost sales do matter, and the pass-on rate should be adjusted downwards. In the extreme case in which the plaintiff's industry is fully cartelized ($\lambda = 1$), the output effect actually fully offsets the pass-on effect and the discount to the overcharge becomes zero. The passing-on defense would thus not be justified, as has also been observed for this extreme case by Hellwig [2006] and Kosicki and Cahill [2006].

We now apply two standard oligopoly models to the plaintiff's industry to show how these results can be made operational: Bertrand competition and quantity competition with conjectural variations (with Cournot competition as a special case). Applications to other symmetric models may also be possible, e.g., bilateral oligopoly with negotiated prices.

### IV(i). *Bertrand Competition*

With Bertrand competition in the plaintiff's industry, each firm chooses its price to maximize its own profits, taking as given the prices set by the other

[12] While the discount to the overcharge is generally positive (unless $\lambda = 1$), it is not necessarily less than one. The discount may be greater than one if the pass-on rate $\tau > 1$ and if $\lambda$ is sufficiently small. In this case, the plaintiff would actually *gain* from the common cost increase due to the cartel.

firms. Market power then stems from the degree of product differentiation and the number of competing firms. Let the plaintiff's own demand when it sets a price $p$ and its rivals all set the same price $r$ be $D(p, r)$. If $p = r$, we obtain the Chamberlinian $DD$ curve, $D(p, p) = H(p)$. The first-order condition defining a symmetric Bertrand-Nash equilibrium is:

$$(7) \qquad (p - c)\frac{\partial D(p,p)}{\partial p} + D(p,p) = 0.$$

Define the plaintiff's firm-level own-price elasticity of demand, evaluated at equal prices $p = r$, as $\eta = -\frac{\partial D(p,p)}{\partial p}\frac{p}{D(p,p)}$. Furthermore, define $\delta = -\frac{\partial D(p,p)}{\partial r}/\frac{\partial D(p,p)}{\partial p}$, i.e., the ratio of the cross-price effect of a price increase by the rivals over the own-price effect. If there are no income effects, the firms' cross-price effects are symmetric, so that $\delta$ can be interpreted as the plaintiff's aggregate diversion ratio, i.e., the fraction of the sales lost by the plaintiff after a price increase that flows back to its rivals in the industry.[13] Differentiating $D(p, r)$ and $H(p)$ and evaluating at equal prices $p = r$, one can verify that the industry-level price elasticity $\varepsilon$ is related to the product-level own-price elasticity $\eta$ through $\varepsilon = \eta(1 - \delta)$. The Bertrand-Nash equilibrium condition (7) can then be written in the following two ways:

$$\begin{aligned}\frac{p-c}{p} &= \frac{1}{\eta} \\ &= \frac{1-\delta}{\varepsilon}.\end{aligned}$$

Substituting this in (4), we obtain $\lambda = \frac{\varepsilon}{\eta} = 1 - \delta$. We can then apply the discount formula (6) to obtain the following corollary to Proposition 1:

*Corollary 1.* In a symmetric Bertrand industry with a common cost increase the appropriate discount to the price overcharge is:

$$(8) \qquad \begin{aligned}\text{discount} &= \left(1 - \frac{\varepsilon}{\eta}\right)\tau \\ &= \delta\tau.\end{aligned}$$

The first expression shows that the discount can be obtained by adjusting the pass-on rate using information on the firm-level and market-level price

[13] To see this formally, we need some additional demand notation. Let $D_i(\mathbf{p})$ be firm $i$'s own demand as a function of the vector of prices set by all firms $\mathbf{p}$. The aggregate diversion ratio of firm $i$ is defined as $-\sum_{j\neq i}\frac{\partial D_j(\mathbf{p})}{\partial p_i}/\frac{\partial D_i(\mathbf{p})}{\partial p_i}$. With symmetric price effects $\frac{\partial D_j(\mathbf{p})}{\partial p_i} = \frac{\partial D_i(\mathbf{p})}{\partial p_j}$, we can write this as $-\sum_{j\neq i}\frac{\partial D_i(\mathbf{p})}{\partial p_j}/\frac{\partial D_i(\mathbf{p})}{\partial p_i}$ which is indeed equal to $\delta = -\frac{\partial D(p,p)}{\partial r}/\frac{\partial D(p,p)}{\partial p}$

elasticities of demand. The using information on the plaintiff's aggregate diversion ratio. For example, if $\tau = 60\%$ and $\delta = 50\%$, the defendant can claim a 30% discount from the price overcharge.

*Example: logit demand.* To illustrate, consider the logit model, which has been popular in many areas of antitrust analysis; see for example Werden and Froeb [1994]. There are $N$ symmetrically differentiated products and one outside good, the no-purchase alternative. There are $L$ potential consumers who either buy one of the differentiated products, or the 'outside good' at an exogenous price $p_0$. The plaintiff's own demand as a function of its own price $p$ and the identical rivals' prices $r$ is

$$D(p, r) = \frac{\exp(-p)}{\exp(p_0) + \exp(-p) + (N-1)\exp(-r)} L,$$

and its portion of total industry demand as a function of a common industry price (the Chamberlinian $DD$ curve) is:

$$H(p) = \frac{\exp(-p)}{\exp(p_0) + N\exp(-r)} L = s(p)L,$$

where $s(p)$ is the plaintiff's market share in the total number of potential consumers. One can easily verify that $\eta = s(p)(1 - s(p))p$, and $\varepsilon = s(p)(1 - Ns(p))p$. This implies that $\lambda = \frac{1-Ns(p)}{1-s(p)}$, so that the discount to the overcharge is

$$\text{discount} = \frac{(N-1)s(p)}{1-s(p)} \tau.$$

This discount can be computed using information on the pass-on rate, the number of firms and the plaintiff's market share in the total number of potential consumers.

### IV(ii) *Quantity Competition with Conjectural Variations*

Now suppose that the firms in the plaintiff's industry compete according to a homogeneous goods quantity competition model with conjectural variations. Let $p = P(Q)$ denote the inverse industry demand function, where $Q =_{i=1}^{N} q_i$ is total industry output, i.e., the sum of the quantities produced by the $N$ firms. In the standard Cournot model, each firm chooses its quantity to maximize its profits, taking as given the quantities of the other firms. In the conjectural variations extension, each firm 'conjectures' that a change in its own quantity induces the other firms to respond. Let the conjectural variations parameter $\theta$ be each firm's conjectured change in total output $Q$ when a firm changes its own quantity by one unit. The first-order condition defining a symmetric conjectural

variations equilibrium is

$$P(Q) - c + P'(Q)\theta\frac{Q}{N} = 0. \tag{9}$$

This condition nests several well-known special cases. If $\theta = 1$, each firm conjectures that total output increases by the same amount as its own quantity (i.e., it takes the quantities of the other firms as given), so that the standard Cournot condition obtains. If $\theta = N$, each firm conjectures that each rival will fully match a quantity increase, so that the condition of a perfect cartel obtains. If $\theta = 0$, each firm conjectures that the rivals contract their quantities in response to a change in its own quantity, in such a way that total output remains constant. In this case, the condition of perfect competition obtains. Outside such special cases, the conjectural variations model has little game-theoretic appeal, since it aims to capture dynamic responses within a static model. It has, however, often been used in empirical work to estimate the conduct or average collusiveness of firms without having to specify a full dynamic model. The critical debate on the interpretation and estimation of $\theta$ is ongoing, as illustrated by the critical discussions in Bresnahan [1989], Corts [1999] and Reiss and Wolak [2005]. We nevertheless include it here to show how it fits nicely into our framework for computing discounts to the price overcharge.

Using the industry-level price elasticity $\varepsilon = -\frac{1}{P'(Q)}\frac{P(Q)}{Q}$, the conjectural variations equilibrium condition (9) can be rewritten as

$$\frac{p-c}{p} = \frac{\theta}{N}\frac{1}{\varepsilon}.$$

Based on (4), we can compute $\lambda = \frac{\theta}{N}$, and apply this to the discount formula to obtain a second corollary to Proposition 1:

*Corollary 2.* In a symmetric Cournot conjectural variation industry with a common cost increase the appropriate discount to the price overcharge is:

$$\text{discount} = \left(1 - \frac{\theta}{N}\right)\tau. \tag{10}$$

For example, in the standard Cournot model $\theta = 1$, so that only information on the number of firms is required to adjust the pass-on rate and obtain the discount.

## V. FIRM-SPECIFIC COST INCREASE

In a variety of settings it is not appropriate to assume that the cartel leads to a cost increase common to all firms in the plaintiff's industry. First, one or more of the cartel members may be vertically integrated and therefore also be active as a downstream competitor in the plaintiff's industry. Such a firm

could then decide to favour its own downstream unit and only charge a high input price to the downstream competitors.[14] To the extent that such raising rivals' costs behavior would occur, the plaintiff experiences a competitive disadvantage relative to some of its rivals, so that it is no longer appropriate to apply the above analysis of a common cost increase.

Second, the cartel members may not be able to control perfectly the supply of their input. Some of the plaintiff's downstream competitors may be able to purchase their inputs from suppliers outside the cartel, or from foreign suppliers if the cartel is national, etc. The plaintiff then also suffers a competitive disadvantage relative to its rivals, so that the analysis of a common cost increase is again no longer valid.

This motivates an analysis of firm-specific cost increases due to the cartel. The general framework of section 3 still applies, i.e., there is a price overcharge or cost effect, a pass-on effect and an output effect. However, the relative magnitudes of these effects no longer follow the simple relations obtained for common cost increases in section 4. In particular, the output effect becomes potentially more important since the plaintiff loses to other firms in its industry as it passes on part of the cost increase. As we will show, it is even possible that the output effect dominates the pass-on effect.

To obtain concrete insights on firm-specific cost increases, we first consider a Bertrand model with differentiated products and subsequently a Cournot model with homogeneous products.

### V(i). *Bertrand Competition*

There are $N$ price-setting firms, $i = 1 \dots N$, selling differentiated products. Let $I$ be the group of affected firms, i.e., the firms affected by the cost increase due to the cartel. One of these affected firms is the plaintiff, denoted by firm 1. Each firm $i$ sells a single product and sets a price $p_i$, operating at a constant marginal cost $c_i$. Firm $i$'s profits in the but-for world (without the cartel) are

$$\pi_i = (p_i - c_i)D_i(\mathbf{p}),$$

where $q_i = D_i(\mathbf{p})$ is its demand, as a function of the $N \times 1$ price vector $\mathbf{p} = (p_1 \dots p_N)$. Demand is downward sloping $\frac{\partial D_i(\mathbf{p})}{\partial p_i} < 0$, products are gross substitutes $\frac{\partial D_i(\mathbf{p})}{\partial p_k} > 0$ for $k \neq i$, there are no income effects, so that the cross-price effects are symmetric $\frac{\partial D_i(\mathbf{p})}{\partial p_k} = \frac{\partial Dk(\mathbf{p})}{\partial p_i}$, and the Jacobian is negative-definite. Let the diversion ratio between the plaintiff firm 1 and any other firm $k \neq 1$ be $\delta_1^k = -\frac{\partial D_k(\mathbf{p})}{\partial p_1} / \frac{\partial D_1(\mathbf{p})}{\partial p_1}$. This is the fraction of firm 1's lost sales that

[14] It is not obvious whether a vertically integrated firm would actually have an incentive to engage in such foreclosure; see e.g., Rey and Tirole [2006]. So in real antitrust cases, this should be separately investigated on a case by case basis.

diverts to firm $k$ after a price increase by firm 1. Furthermore, let firm 1's aggregate diversion ratio be $\delta_1 = \sum_{k \neq 1} \delta_1^k < 1$, i.e., the fraction of firm 1's lost sales that flows to other firms within the industry.[15]

The system of first-order conditions defining a Bertrand-Nash equilibrium is

$$(11) \qquad (p_i - c_i)\frac{\partial D_i(\mathbf{p})}{\partial p_i} + D_i(\mathbf{p}) = 0, \quad i = 1 \cdots N$$

and assume that the second-order conditions are satisfied. Denote $\mathbf{p} = p^*(\mathbf{c})$ as the price vector that solves (11) as a function of the marginal cost vector $\mathbf{c} = (c_1 \cdots c_N)$. Define $\tau_i^k = \frac{\partial p_k^*(\mathbf{c})}{\partial c_i}$ as the firm-specific pass-on rate of firm $k$ with respect to a cost increase of firm $i$, and assume $\tau_i^k > 0$ for all $i, k$. Furthermore, define $\tau_I^k = \sum_{i \in I} \tau_i^k$ as the group-level pass-on rate of firm $k$, i.e., firm $k$'s pass-on rate with respect to a cost increase of all firms affected by the cartel $i \in I$.

We are interested in the effect of the cartel on the plaintiff firm 1's profits. Firm 1's equilibrium profits as a function of the marginal cost vector $\mathbf{c}$ in the but-for world are

$$\pi_1(\mathbf{c}) = (p_1^*(\mathbf{c}) - c_1)D_1(p^*(\mathbf{c})).$$

Assume that the cartel raises all affected firms' marginal costs by the same amount as the plaintiff and does not affect the others' marginal costs, i.e., $\mathrm{d}c_i = \mathrm{d}c_1$ for $i \in I$ and $\mathrm{d}c_i = 0$ for $i \notin I$. The change in plaintiff firm 1's profits in response to the cartel is then equal to

$$(12) \qquad \begin{aligned} \mathrm{d}\pi_1 &= \sum_{i=1}^{N} \frac{\partial \pi_1(\mathbf{c})}{\partial c_i}\mathrm{d}c_i \\ &= \sum_{i \in I} \frac{\partial \pi_1(\mathbf{c})}{\partial c_i}\mathrm{d}c_1 \\ &= \left(-q_1 + q_1 \sum_{i \in I} \frac{\partial p_1^*}{\partial c_i} + (p_1 - c_1)\sum_{i \in I}\left(\frac{\partial D_1}{\partial p_1}\frac{\partial p_1^*}{\partial c_i} + \cdots \frac{\partial D_1}{\partial p_N}\frac{\partial p_N^*}{\partial c_i}\right)\right)\mathrm{d}c_1. \end{aligned}$$

This reconfirms that the cartel has three effects. The first term is the price overcharge or cost effect and is proportional to minus firm 1's sales, $-q_1$. The second term is the pass-on effect. It is positive and proportional to firm 1's sales, multiplied by the extent to which firm 1 passes on the marginal cost increases of the affected group. The third term is the output effect. It is proportional to firm 1's profit margin, multiplied by the extent to which firm

[15] This is the same as the aggregate diversion ratio $\delta$ defined earlier in the symmetric framework.

1 loses sales through the equilibrium price responses of all firms (both the affected and the unaffected firms).

We now show that the positive pass-on effect dominates the output effect, so that an adjusted passing-on defense is valid under the general conditions of the Bertrand model. To see this, substitute firm 1's first-order condition (11) and the symmetric cross-effects $\frac{\partial D_1}{\partial p_k} = \frac{\partial D_k}{\partial p_1}$ in the profit change (12). Then apply the definitions of the diversion ratios $\delta_1^k$ and the pass-on rates $\tau_I^k$ to obtain:

$$(13) \qquad \mathrm{d}\pi_1 = -\left(1 - \delta_1^2\tau_I^2 - \cdots - \delta_1^N\tau_I^N\right)q_1\mathrm{d}c_1.$$

Equation (13) says that the price overcharge $(-q\mathrm{d}c)$ should be discounted by the amount $\delta_1^2\tau_I^2 + \cdots + \delta_1^N\tau_I^N$. Since $\delta_1^k > 0$ for $k \neq 1$ and $\tau_I^k > 0$, this discount is generally positive. We therefore have:

*Proposition 2*. Consider a Bertrand industry where cost increases for a group of firms $I$ only, including the plaintiff firm 1. The appropriate discount to the price overcharge suffered by plaintiff firm 1 is positive, and is given by

$$(14) \qquad \text{discount} = \delta_1^2\tau_I^2 + \cdots + \delta_1^N\tau_I^N > 0.$$

An adjusted passing-on defense is therefore justified.[16]

The discount to the overcharge (14) reflects the combined pass-on and output effects. Intuitively, it is equal to a weighted-average of the group-level pass-on rates over all firms except the plaintiff firm 1, where the weights are the diversion ratios with respect to firm 1. The adjusted passing-on defense should however be carefully interpreted. It is *not* the fact that plaintiff firm 1 is able to pass on the affected firms' cost increase that justifies resorting to the passing-on defense. This term is actually only a second-order effect because it is fully compensated by an output effect.[17] In contrast, it is that fact that all *other* firms than the plaintiff also raise their prices in response to the cost increases that justifies the passing-on defense. These other firms' price responses are first-order effects and raise the plaintiff's profits through increased output.

The question of practical interest is of course how to measure the discount to the overcharge (14). A first approach is to obtain an econometric estimate of the group-level pass-on rates for all firms that are active in the downstream market. The discount can then be computed from (14) using quantitative or qualitative information on the diversion ratios as weights. This approach may require a substantial amount of information in practice.

[16] The discount may be greater than one if some of the pass-on rates $\tau_I^k > 1$ and the corresponding diversion ratios $\delta_1^k$ are sufficiently close to 1.

[17] Formally, after substituting firm 1's first-order condition (11) the pass-on term $q_1 \sum_{i\in I} \frac{\partial p_1^*}{\partial c_i}$ cancels out with part of the output term in (12).

As an alternative, one may make additional assumptions to obtain a more explicit expression of the discount formula. We discuss two examples next. *Identical firms without the cartel*. Suppose that all firms in the plaintiff's industry are identical in the but-for world, and are correspondingly in a symmetric Bertrand-Nash equilibrium. The cartel subsequently raises the marginal costs of the firms in the affected group $I$. With identical firms in the but-for world, the group-level pass-on rates are all equal, i.e., $\tau_I^k = \tau_I$ for all $k$. Using the aggregate diversion ratio $\delta_1 = \sum_{k \neq 1} \delta_1^k$, the discount formula (14) simplifies to

$$\text{discount} = \delta_1 \tau^I. \tag{15}$$

This generalizes our earlier discount formula (8) for the symmetric Bertrand industry with a common cost increase. The crucial difference is that the group-level pass-on rate $\tau^I$ now enters instead of the industry-level pass-on rate $\tau$. Since the group-level pass-on rate is typically lower than the industry-level pass-on rate, the discount to the overcharge is clearly also lower.

*Symmetric substitution patterns and logit demand*. Now allow firms to be different, but assume that the demand side is characterized by symmetric substitution patterns. This means that a loss in the market share of plaintiff firm 1 (or of any other firm) is associated with an increase in the market shares of the rivals in proportion to their market shares. This is a property of random utility discrete choice models of demand, when the independence of irrelevant alternatives (IIA) assumption is satisfied. The diversion ratio between firm 1 and firm $k$ is then equal to $\delta_1^k = \frac{s_k}{1-s_1}$, where $s_k$ is the market share of firm $k$ in the total number of potential consumers $L$. The discount (14) can then be written as

$$\text{discount} = \frac{1}{1-s_1}\left(s_2\tau_I^2 + \cdots + s_N\tau_I^N\right). \tag{16}$$

Hence, the discount equals the weighted average of the rivals' pass-on rates where the market shares are the weights. Equivalently, one can interpret this discount as the effect of the affected firms' cost increase on the price index for the whole industry except firm 1 (using fixed market shares as weights).

To avoid econometric estimation of the pass-on rates, one may further specify the demand model and compute the pass-on rates as a function of observables or a limited set of parameters. To illustrate this, consider the earlier discussed logit model of demand, but now allowing firms to differ in quality or costs. The logit model satisfies the IIA assumption and correspondingly entails symmetric substitution patterns. In the Appendix we derive explicit formula for the pass-on rates $\tau_i^k$ as a function of observable market shares $s_i$, i.e., shares of each firm $i$ in the total potential sales. Substituting these in (16) and rearranging, one can write the formula for the

discount as:

$$\text{(17)} \qquad \text{discount} = \frac{\sum_{i \in I} T_i - s_1(1 - s_1)}{(1 - s_1)^2 + s_1},$$

where

$$T_i = \frac{s_i(1 - s_i)^2}{(1 - s_i)^2 + s_i} \Bigg/ \left( s_0 + \sum_{k=1}^{N} \frac{s_k(1 - s_k)^2}{(1 - s_k)^2 + s_k} \right),$$

and $s_0$ is the market share of the outside good.[18] This shows that the discount to the price overcharge can be computed using only information on the market shares of all firms, including the outside good, and on the identity of the affected firms. While the market share of the outside good is typically not known, it can be calibrated using information on the market-level price elasticity of demand. For example, if the market-level elasticity is approximately zero, then $s_0 = 0$.

One can immediately verify that the logit discount is indeed always positive. In addition, the discount is always less than 1. Furthermore, it approaches 1 if there is a common cost increase and perfectly inelastic industry-level demand (i.e., the number of affected firms is equal to $N$ and the market share of the outside good $s_0 \to 0$).

To gain additional intuition on the logit discount formula, Table I computes the discounts for alternative values of the number of firms in the plaintiff's market, the number of unaffected firms, and the plaintiff's market share. The table assumes that the outside good has a market share of 10%, that the plaintiff firm 1 has a market share of either 10% or 50%, and that the other firms share the rest of the market equally. The table confirms that the discount is less than 100% but always positive, even if all firms except the plaintiff are unaffected (bold numbers on diagonal). We can make three additional observations. First, a comparison across the rows shows that the discount decreases with the number of unaffected firms. Second, a comparison across the columns shows that the discount increases with the degree competition in the plaintiff's market (holding the number of unaffected firms constant). Third, a comparison between the left and right panel shows that the discount is often larger if plaintiff has a small market share. To illustrate its practical relevance, we apply the logit discount formula to the European vitamin cartel in section 6.

[18] The market share of the outside good enters the discount formula differently from the other shares, because the price of this product remains constant after the cost change unlike the prices of the other products.

TABLE I
DISCOUNT TO THE COST EFFECT OF THE CARTEL: BERTRAND COMPETITION

| | Plaintiff's market share: 10% | | | Plaintiff's market share: 50% | | |
|---|---|---|---|---|---|---|
| | Number of firms in the plaintiff's market | | | | | |
| Unaffected firms | 2 | 6 | 10 | 2 | 6 | 10 |
| logit demand | | | | | | |
| 0 | 52% | 87% | 88% | 71% | 79% | 79% |
| 1 | **33%** | 70% | 78% | **15%** | 63% | 71% |
| 5 | – | **2%** | 40% | – | **2%** | 36% |
| 9 | – | – | **1%** | – | – | **1%** |

Notes: The numbers are based on the discount formula (17). The market shares are as follows: outside good = 10%; plaintiff = 10% or 50%; other firms: identical share of remaining part. The numbers in bold refer to common cost increases (all firms are insiders).

### V(ii). *Cournot Competition*

There are $N > 1$ quantity-setting firms, selling a homogeneous product. Let $I$ again be the group of affected firms, and let $N_I$ be the number of affected firms. One of the affected firms is the plaintiff, again denoted by firm 1. Each firm $i = 1 \ldots N$ produces a quantity $q_i$ at a constant marginal cost $c_i > 0$. Total industry output is $Q = \sum_{k=1}^{N} q_k$ and the average of all firms' marginal costs is $\bar{c} = \sum_{k=1}^{N} c_k / N$. Let the inverse industry demand function be $p = P(Q)$, with $P'(Q) < 0$. The price elasticity of industry demand is $\varepsilon = -\frac{1}{P'(Q)} \frac{P(Q)}{Q}$. A measure of the curvature of industry demand is the elasticity of the slope of the inverse demand curve, i.e., $\rho = -P''(Q)\frac{Q}{P'(Q)}$; see e.g., Vives [1999]. If $\rho < 0$, demand is concave; if $\rho = 0$, demand is linear; and if $\rho > 0$, demand is convex. A well-known example of convex demand is the constant elasticity demand case, for which $\rho = \frac{1+\varepsilon}{\varepsilon}$.[19] Each firm $i$ chooses to produce its quantity $q_i$ to maximize profits

$$\pi_i = (P(Q) - c_i)q_i,$$

taking as given the quantities chosen by the rival firms. The system of necessary first-order conditions defining a Cournot-Nash equilibrium is

$$(18) \qquad P(Q) - c_i + P'(Q)q_i = 0, \quad i = 1 \ldots N.$$

Assume that $P'(Q) + P''(Q)q_i \leqslant 0$ for all $i$. Given constant marginal costs $c_i$, this assumption ensures the existence of a unique Cournot-Nash

[19] An often-used related measure for the demand curvature is the elasticity of the elasticity. This is defined by $E = \varepsilon'(Q)\frac{1}{P'(Q)}\frac{P(Q)}{\varepsilon(Q)}$. It can be verified that $\rho = \frac{\varepsilon+1-E}{\varepsilon}$. Our measure gives simpler expressions below.

equilibrium.[20] The assumption is equivalent to $1 - \rho s_i \geqslant 0$ for all $i$, where $s_i = q_i/Q$ is firm $i$'s market share. It also implies that $N - \rho \geqslant 0$.

To perform comparative statics of the cost increase due to the cartel, first define the equilibrium quantities and price as a function of the marginal costs. Adding up the first-order conditions gives

$$(19) \qquad (P(Q) - \overline{c})N + P'(Q)Q = 0.$$

Under the above assumptions, the left-hand-side of (19) is decreasing in $Q$ and $\overline{c}$ and implicitly defines the equilibrium industry output function, $Q = Q^*(\overline{c})$, decreasing in $\overline{c}$. Furthermore, using the inverse industry demand function, we can also define the equilibrium price function $p = p^*(\overline{c}) = P(Q^*(\overline{c}))$, increasing in $\overline{c}$. Implicitly differentiating (19), using the definition of $\rho$, and rearranging, we obtain

$$(20) \qquad \tau = \frac{\partial p^*(\overline{c})}{\partial \overline{c}} = \frac{N}{N + 1 - \rho}.$$

This can be interpreted as the industry-level pass-on rate since $\tau = \frac{\partial p^*(\overline{c})}{\partial \overline{c}} = \sum_{i=}^{N} \frac{\partial p^*(\overline{c})}{\partial \overline{c}} \frac{\partial \overline{c}}{\partial c_i}$. Note that $\tau > 0$ since $N + 1 - \rho > N - \rho \geqslant 0$. Note also that pass-on is incomplete, i.e., $\tau < 1$, if and only if $\rho < 1$. Finally, substituting $Q = Q^*(\overline{c})$ in the first-order condition (18) gives

$$(21) \qquad P(Q^*(\overline{c})) - c_i + P'(Q^*(\overline{c}))q_i = 0.$$

Equation (21) implicitly defines firm $i$'s equilibrium output function $q_i = q_i^*(\overline{c}, c_i)$. Under the above assumptions (21) is decreasing in $q_i$, increasing in $\overline{c}$ and decreasing in $c_i$, so that $q_i^*(\overline{c}, c_i)$ is increasing in $\overline{c}$ and decreasing in $c_i$.

As before, we are interested in the effect of the cartel on the plaintiff firm 1's profits. Firm 1's equilibrium profits in the but-for world can be written as a function of the average of all firms' marginal costs $\overline{c}$ and its own marginal cost $c_1$:

$$\pi_1(\overline{c}, c_1) = (p^*(\overline{c}) - c_1)q_1^*(\overline{c}, c_1).$$

Assume again that the cartel affects the marginal costs of all firms in the affected group by the same amount as the plaintiff and does not affect the other firms, $\mathrm{d}c_i = \mathrm{d}c_1$ for $i \in I$ and $\mathrm{d}c_i = 0$ for $i \notin I$. The change in plaintiff

[20] Vives [1999] provides a more detailed discussion of these and weaker conditions for the existence, uniqueness and stability of Cournot equilibrium.

firm 1's profits in response to the cartel then equals

$$\begin{aligned} \mathrm{d}\pi_1 &= \sum_{i=1}^{N} \frac{\partial \pi_1(\overline{c}, c_1)}{\partial c_i} \mathrm{d}c_i \\ &= \sum_{i \in I} \frac{\partial \pi_1(\overline{c}, c_1)}{\partial c_i} \mathrm{d}c_1 \\ &= \left( -q_1 + q_1 \sum_{i \in I} \left( \frac{\partial p^*}{\partial \overline{c}} \frac{1}{N} \right) + (p - c_1) \sum_{i \in I} \left( \frac{\partial q_1^*}{\partial \overline{c}} \frac{1}{N} + \frac{\partial q_1^*}{\partial c_i} \right) \right) \mathrm{d}c_1. \end{aligned} \tag{22}$$

The first term is the price overcharge or the cost effect of the cartel and is clearly negative. The second term is the group-level pass-on effect and it is positive since $\tau > 0$. Using (20), it can be written as $q_1 \frac{N_I}{N} \tau$, i.e., it is proportional to the industry-wide pass-on rate times the fraction of affected firms $\frac{N_I}{N}$. The third term is the output effect and is typically negative.

We now show that in contrast to the Bertrand model, the negative output effect may be so strong that it actually dominates the positive pass-on effect. This implies that the discount to the price overcharge may actually be negative, i.e., the plaintiff may actually incur damages that are *larger* than the price overcharge. A passing-on defense may therefore no longer necessarily be justified.

To see this, we follow the same approach as in the Bertrand case and rewrite firm 1's profit change (22), after substituting firm 1's first-order condition from (18), substituting the pass-on expression (20), and performing the required implicit differentiations $\frac{\partial q_1^*(\overline{c}, c_i)}{\partial \overline{c}}$ and $\frac{\partial q_1^*(\overline{c}, c_i)}{\partial c_i}$ on (21). This gives:

$$\mathrm{d}\pi_1 = -\left( 1 - \left( \frac{2 - \rho s_1}{N + 1 - \rho} N_I - 1 \right) \right) q_1 \mathrm{d}c_1. \tag{23}$$

Equation (23) implies that the price overcharge $(-q_1 \mathrm{d}c_1)$ should be discounted by the amount $\frac{2 - \rho s_1}{N + 1 - \rho} N_I - 1$. It is easy to see that this discount is not necessarily positive, i.e., the pass-on effect may be fully dominated by the output effect. For example, under linear demand ($\rho = 0$) the discount is negative if and only if the number of $N_I < \frac{N+1}{2}$. As another example, under constant and unitary elasticity demand ($\varepsilon = 1$ and $\rho = 1 + \frac{1}{\varepsilon} = 2$) the discount is negative if and only if $N_I < \frac{N-1}{2(1-s_1)}$. Intuitively, in the Cournot model negative discounts to the price overcharge may arise and invalidate the passing-on defense because the unaffected firms respond aggressively by expanding their output when the plaintiff and the other affected firms reduce output after the cost increase. These aggressive output responses may make the output effect fully dominate the pass-on effect. We therefore have:

*Proposition 3*. Consider a Cournot industry where cost increases for a group of firms $I$ only, including the plaintiff firm 1. The appropriate discount to the

price overcharge suffered by plaintiff firm 1 may be positive or negative, and is given by

$$\text{discount} = \frac{2 - \rho s_1}{N + 1 - \rho} N_I - 1 \lessgtr 10 \tag{24}$$

An adjusted passing-on defense is therefore not necessarily justified.[21]

The discount formula (24) is written in terms of the demand curvature condition $\rho$. Using (20), it is however also possible to rewrite it in terms of the pass-on rate $\tau$. This gives:

$$\text{discount} = (1 - s_1)\frac{N_I}{N}\tau - (1 - Ns_1)\left(1 - \frac{N_I}{N}\tau\right) - Ns_1\left(1 - \frac{N_I}{N}\right).$$

This formula may be preferred if $\rho$ is difficult to observe and instead an estimate of $\tau$ is available. This is also how we expressed the discount formulas for the Bertrand model or for the symmetric models with a common cost increase.[22]

Because of the Cournot assumption $1 - \rho s_i \geqslant 0$ for all $i$, we have $\frac{2-\rho s_1}{N+1-\rho} > 0$. This immediately implies that the discount (24) increases as the number of affected firms $N_I$ increases. It is not obvious, however, how many affected firms are required for the discount to become positive and a passing-on defense to be justified. This depends on the plaintiff's market share $s_1$, on the number of firms $N$ and especially on the curvature of demand $\rho$, of which both the sign and the magnitude are unknown and difficult to measure empirically (since it captures a second-order property of the demand curve). We can nevertheless show:

*Proposition 4*. (a) In a Cournot industry with a common cost increase ($N_I = N$), the discount is positive and hence an adjusted passing-on defense is justified unless $\rho < -(N-1)$ and $s_1 < \frac{1}{N} - \frac{N-1}{N}\frac{1}{(-\rho)}$.

(b) In a Cournot industry with a cost increase to the plaintiff only ($N_I = 1$), the discount is negative and hence an adjusted passing-on defense is not justified unless $\rho > (N-1)$ and $s_1 < \frac{1}{N} - \frac{N-1}{N}\frac{N-\rho}{\rho}$.

*Proof*. See the Appendix. ■

[21] Furthermore, the discount may be greater than one, if demand is sufficiently convex.

[22] Note that if the cost increase applies to all firms $N_I = N$, and the plaintiff has a symmetric market share $s_1 = \frac{1}{N}$, the second and third terms vanish so that the discount reduces to our earlier symmetric Cournot formula (10) (with $\theta = 1$).

Proposition 4 provides easy to interpret necessary and sufficient conditions under which the passing-on defense is justified after a common cost increase ($N_I = N$) and not justified after a cost increase to the plaintiff only ($N_I = 1$). While a cost increase to the plaintiff only is clearly not representative for most cartels, it serves as a benchmark to stress that a passing-on defense against a Cournot plaintiff is only valid if a sufficiently large number of firms is affected by the cartel.
Proposition 4 can be simplified to the following possible sufficient conditions:

*Corollary 3*. For the Cournot industry suppose that one of the following conditions applies: (*i*) $-(N-1) \leqslant \rho \leqslant N-1$ or equivalently $\frac{1}{2} < \tau < \frac{N}{2}$; or (*ii*) $s_1 \geqslant \frac{1}{N}$. An adjusted passing-on defense is then always justified after a common cost increase ($N_I = N$) and never justified after a cost increase to the plaintiff only ($N_I = 1$).

*Proof*. The demand curvature condition $-(N-1) \leqslant \rho \leqslant N-1$ follows immediately from Proposition 4, and is equivalent to the condition on the pass-on rate $\frac{1}{2} \leqslant \tau \leqslant \frac{N}{2}$ by (20). The market share condition $s_1 \geqslant \frac{1}{N}$ also follows immediately, since both market share thresholds in Proposition 4 are below $\frac{1}{N}$. ■

The demand curvature condition on $\rho$ (or the equivalent pass-on rate condition) is satisfied for a wide range of demand functions, including linear and exponential demand, but not necessarily under constant elasticity demand. The market share condition generalizes our earlier result of Corollary 2 that the passing-on defense is justified in a symmetric Cournot model with a common cost increase:[23] this continues to be true in an asymmetric Cournot model as long as the plaintiff has a higher than average market share. In sum, under a wide variety of circumstances the passing-on defense is justified when all firms are affected by the cost increase, and not justified when only the plaintiff is affected. This shows the key importance of assessing how many firms have been affected by the cost increase before resorting to the passing-on defense in a Cournot industry.

*Specific functional forms of demand*. A more concrete picture of the discount formula (24) and our subsequent results emerges from specific functional forms of demand. Consider Genesove and Mullin's [1998] demand specification $Q = \beta(\alpha - p)^\gamma$, according to which the demand curvature is $\rho = \frac{\gamma-1}{\gamma}$. This specification nests various special demand functions with an

[23] This is the special case for which $N_I = N$ and $s_i = \frac{1}{N}$ for all $i$.

TABLE II
DISCOUNT TO THE COST EFFECT OF THE CARTEL: COURNOT COMPETITION

| | Plaintiff's market share: $s_1 = 10\%$ | | | Plaintiff's market share: $s_1 = 50\%$ | | |
|---|---|---|---|---|---|---|
| | Number of firms in the downstream market ($N$) | | | | | |
| Unaffected firms | 2 | 6 | 10 | 2 | 6 | 10 |
| linear demand ($\rho = 0$, so $\tau = \frac{N}{N+1}$) | | | | | | |
| 0 | 33% | 71% | 82% | 33% | 71% | 82% |
| 1 | **– 33%** | 43% | 64% | **– 33%** | 43% | 64% |
| 5 | | **– 71%** | – 9% | | **– 71%** | – 9% |
| 9 | | | **– 82%** | | | **– 82%** |
| quadratic demand ($\rho = \frac{1}{2}$, so $\tau = \frac{N}{N+1/2}$) | | | | | | |
| 0 | 56% | 80% | 86% | 40% | 62% | 67% |
| 1 | **– 22%** | 50% | 67% | **– 30%** | 35% | 50% |
| 5 | | **– 70%** | – 7% | | **– 73%** | – 17% |
| 9 | | | **– 81%** | | | **– 83%** |
| exponential demand ($\rho = 1$, so $\tau = 1$) | | | | | | |
| 0 | 90% | 90% | 90% | 50% | 50% | 50% |
| 1 | **– 5%** | 58% | 71% | **– 25%** | 25% | 35% |
| 5 | | **– 68%** | – 5% | | **– 75** | – 70% |
| 9 | | | **– 81%** | | | **– 85%** |
| log-linear demand with $\varepsilon = 2$ ($\rho = \frac{3}{2}$, so $\tau = \frac{N}{N-1/2}$) | | | | | | |
| 0 | 147% | 102% | 95% | 67% | 36% | 32% |
| 1 | **23%** | 68% | 75% | **– 17%** | 14% | 18% |
| 5 | | **– 66%** | – 3% | | **– 77%** | – 31% |
| 9 | | | **– 81%** | | | **– 87%** |

Notes: The numbers are based on the discount formula (24) after substituting the relevant demand parameters $\rho$. The market shares are as follows: plaintiff = 10% or 50%; other firms: identical share of remaining part. The numbers in bold refer to common cost increases (all firms are insiders).

increasingly convex curvature: linear demand ($\gamma = 1$, so that $\rho = 0$), quadratic demand ($\gamma = 2$, so that $\rho = \frac{1}{2}$), exponential demand ($\alpha, \gamma \to \infty, \frac{\alpha}{\gamma}$ constant, so that $\rho = 1$), and log-linear or constant elasticity demand ($\alpha = 0$, $\gamma < 0$, so that $\rho = 1 + \frac{1}{\varepsilon}$). We then have incomplete pass-on ($\tau < 1$) for linear and quadratic demand; complete pass-on ($\tau = 1$) for exponential demand; and more than complete pass-on ($\tau > 1$) for log-linear demand.

Table II computes the discount to the price overcharge for these four demand specifications, for alternative values of the number of firms $N$, the number of unaffected firms $N - N_I$, and the plaintiff's market share $s_1$ (either 10% or 50%).[24] Table II confirms our findings summarized in Propositions 3 and 4 and Corollary 3. In contrast to the Bertrand model, the discount is not generally positive. It is, however, positive for a common cost increase (no unaffected firms, on first row of each panel). It decreases as the number of unaffected firms increases and it is almost always negative for a cost increase to the plaintiff only (all firms but the plaintiff are unaffected, bold numbers

[24] The elasticity is irrelevant for the results in all specifications, except under log-linear demand. In that case, we set it equal to 2 so that $\rho = 1 + \frac{1}{\varepsilon} = \frac{3}{2}$.

on diagonal).[25] Table II also illustrates how the discount varies in a complex way with the number of competing firms $N$, the plaintiff's market share $s_1$ and especially how this interacts with the demand curvature $\rho$. When the plaintiff has a small market share of 10%, the most conservative discounts obtain in the linear demand case, and they increase as demand becomes more convex. The reverse is true however when the plaintiff has a large market share of 50% and the number of firms is sufficiently large (6 or 10).[26] This discussion shows the importance of a robustness analysis in applying the passing-on defense when the demand curvature $\rho$ is not observed. Alternatively, one may indirectly retrieve $\rho$ from an empirical estimate of the pass-on rate $\tau$ and applying the pass-on formula (20).

## VI. EMPIRICAL ILLUSTRATION: THE EUROPEAN VITAMIN CARTEL

In its decision of 21 November, 2001, the European Commission issued large fines to several vitamin producers for participating in a cartel during 1989–1999. Premixing companies were important customers, as they require vitamines in their production of nutritional additives. To quantify their potential damages, it is not relevant to just measure the price overcharge from the cartel. One should also ask whether the premixers were capable of passing on part of this overcharge to their own customers (the compound feed producers) and whether such a passing-on would hurt their sales. To show how our analysis can shed light on this, we calculate discounts to the price overcharge, solely based on information from the public domain. We use two sources of information for the vitamin cartel and the premixing market: the 2001 European Commission's Decision regarding the vitamin cartel, and a 2001 U.K. Competition Commission Report regarding a merger between two vitamin producers (BASF and Takeda Chemicals).

To illustrate the methodology, assume that the premixing market can be described by Bertrand price competition with differentiated products according to the logit demand model of section 5.1. This implies that (17) is the relevant formula for the discount to the price overcharge. Formula (17) requires the following information. First, we need to know the premixers and their market shares. The U.K. Competition Commission Report describes the following premixers and their market shares: Roche, Frank

[25] There is only one case with a positive discount (23%) after a cost increase to the plaintiff, i.e., under the log-linear demand with $N = 2$, $N_I = 1$ and plaintiff's market share $s_1 = 0.1$. In this case, the two possible sufficient conditions of Corollary 7 are violated since (i) $\rho = \frac{3}{2} > 1$, and $s_1 = 0.1 > \frac{1}{2}$.

[26] Furthermore, for linear and quadratic demand, the discount increases as the number of competing firms $N$ increases, as in the Bertrand case. This is also true for exponential demand if there is at least one outsider. However, for exponential demand without an outsider, the discount is independent of the number of competitors. Furthermore, for log-linear demand, the discount may actually decrease as competition increases.

TABLE III
AN ADJUSTED PASSING-ON DEFENSE AGAINST PREMIXERS IN THE VITAMIN CARTEL

| | | Required discount to the price overcharge | | |
|---|---|---|---|---|
| | | Firms unaffected by the price overcharge | | |
| | Market share | – | Roche | Roche and Frank Wright |
| Roche | 26 | – | – | – |
| Frank Wright | 30 | – | – | – |
| Trouw | 15 | 90.4 | 65.5 | 39.0 |
| Premier | 12 | 90.7 | 66.3 | 40.4 |
| Nutec | 10 | 90.8 | 66.9 | 41.1 |
| Others | 7 | 91.1 | 67.7 | 42.8 |

Notes: All numbers are percentages. Market shares in first column are averages based on U.K. Competition Commission Report, Ch. 4, p. 83, Table 4.16. The market share of the outside good is set equal to the market share of 'others' and shares are subsequently rescaled to add up to 100%. Discounts to Roche and Frank Wright are irrelevant as they are integrated with the vitamin producers.

Wright, Trouw, Premier, Nutec and 'all others.' The first column of Table III summarizes the information on their market shares. Second, we need information on the market share of the outside good (the no-purchase alternative). The U.K. Competition Commission report suggests that there are few substitutes for premix (para 4.182). We therefore set the market share of the outside good at a relatively low level. (We choose it to be equal to the market share of all other premixers.)

Finally, we need to know which premixers were affected by the cartel. Two premixers are vertically integrated with vitamin producers and may therefore not have been affected: Roche throughout the cartel period and Frank Wright since 1997 (as it was acquired by BASF in 1996). In principle, an upstream firm (vitamin producer) would not necessarily want to favour its own downstream business (premixing unit), since this might entail productive or demand distortions. In the case of a cartel, the vertically integrated firms might however find such favouring advantageous as it would provide an opportunity to cheat from the cartel. However, the European Commission Decision describes in some detail (e.g., para 225) that the cartel members were aware of this problem. They had a quota system which included vitamin sales of the vertically integrated firms to their own downstream subsidiaries. This is further supported by some empirical evidence: Frank Wright did not see its premix market share increase after it was acquired by BASF. While there are therefore no compelling reasons to think that Roche and Frank Wright were unaffected by the cartel, we allow for this possibility by considering three scenarios. In the first scenario all premixers were affected by the overcharge, in the second Roche was not affected and in the third both Roche and Frank Wright were unaffected.

Table III shows the discounts to the price overcharge as implied by (17). If all premixers are affected (second column), the appropriate discounts to the price overcharge are around 90%. In other words, only around 10% of the

cartel price overcharge is then suffered as damages to premixers. In contrast, if Roche's premixing subsidiary were not affected, the discounts would drop to about 66–68%. Intuitively, this is because the premixers would be more constrained in passing on the price overcharge as they would lose business to Roche. Finally, if both Roche and Frank Wright would not be affected, the discounts would drop to about 39–43%.

These calculations are largely based on market shares and assumptions about competition in the premixing market. A more complete analysis would aim to estimate directly the extent of pass-on, based on historical information about vitamin prices and premix prices. The estimated degree of pass-on could then be inserted as $\sum_{i\in I} T_i$ in (17), so that market shares are only necessary for computing the adjustments for the output effect. If such information were not available, it would be warranted to perform an extensive further sensitivity analysis regarding the premixing market, e.g., by considering alternative models of competition.

## VII. THE CARTEL'S TOTAL HARM

Our analysis has so far exclusively looked at the cartel's effects on the profits of one direct purchaser. In a recent paper, Basso and Ross [2007] take a different focus and analyze the total harm of the cartel. This is the harm to the affected parties, i.e., all direct purchasers and their consumers. They show that the total harm is larger than the traditional price overcharge, especially when the direct purchasers have a lot of market power. Their analysis is complicated by the fact that they allow for a large price overcharge. Based on our differential approach, which looks at 'small' price overcharges, we now show that the total harm exceeds the price overcharge by an amount that is equal to our output effect.

We return to the case of a common cost increase of section 4, but now consider the cartel's effect on all direct purchasers and on their consumers. As before, total industry demand when all firms set the same price $p$ is $Q = Q(p)$. Furthermore, let aggregate consumer surplus be $v(p)$. The downstream industry equilibrium price as a function of the common marginal cost $c$ is again $p = p^*(c)$. The affected parties' surplus as a function of marginal cost $c$ is the sum of downstream industry profits $\Pi(c)$ and aggregate consumer surplus $v(p^*(c))$:

$$\begin{aligned} S(c) &= \Pi(c) + v(p^*(c)) \\ &= (p^*(c) - c)Q(p^*(c)) + v(p^*(c)). \end{aligned}$$

Note that because of our focus on the direct purchasers and consumers, this surplus function does not include the cartel's profits, so it does not represent total welfare.

The cartel's total harm is the change in the affected parties' surplus due to the cartel's overcharge or cost increase d$c$:

$$\mathrm{d}S = \left(-Q + Q\frac{\partial p^*(c)}{\partial c} + (p-c)\frac{\partial Q(p)}{\partial p}\frac{\partial p^*(c)}{\partial c}\right)\mathrm{d}c + \frac{\partial v(p)}{\partial p}\frac{\partial p^*(c)}{\partial c}\mathrm{d}c.$$

There are two components. First, the cartel's effect on direct purchasers consists of the price overcharge and the pass-on and output effects. This parallels our previous analysis of the purchaser plaintiff's profit effects, now at the aggregate industry level; see (3) in section 4. Second, the effect on consumers is the pass-on effect, as transferred by the cartel's direct purchasers. Applying the aggregate version of Roy's identity, $Q = -\frac{\partial v(p)}{\partial p}$, and using our earlier defined price elasticity of demand $\varepsilon$, pass-on rate $\tau$ and competition intensity parameter $\lambda$, the cartel's total harm can be written as:

$$\begin{aligned} \mathrm{d}S &= -(1-(1-\lambda)\tau)Q\mathrm{d}c - \tau Q\mathrm{d}c \\ &= -(1+\lambda\tau)Q\mathrm{d}c. \end{aligned} \tag{25}$$

The final consumers are hurt by the extent of pass-on $\tau$, but this is merely a transfer from the cartel's purchasers so it cancels out in the second line of (25). The total harm is therefore the price overcharge, plus a percentage *premium* $\lambda\tau$. In fact, this premium is equal to the output effect that was also used in the downward adjustment of the discount when applying a passing-on defense to the purchaser plaintiff. We therefore have:

*Proposition 5*. Consider a symmetric industry with a common cost increase due to the cartel. The total harm from the cartel consists of the price overcharge to the downstream industry, plus a percentage premium of $\lambda\tau$. This premium is equal to the output effect.

The result that the total harm from the cartel is larger than the price overcharge is consistent with Basso and Ross [2007]. We show that this premium (or multiplier, as they call it) is equal to the output effect and can be nicely written in terms of the pass-on rate $\tau$ and our competition intensity parameter $\lambda$. Interestingly, an adjusted passing-on defense against the purchaser plaintiffs may therefore actually turn against the defendant, since the evidence required to adjust for the output effect in the passing-on defense may also be used to demonstrate by how much the cartel's total harm exceeds the price overcharge.

We can also briefly relate our approach to two other recent papers. Boone and Müller [2008] take as given the total harm from the cartel, to focus on the question how this total harm is distributed between the direct purchasers

and final consumers. If firms are symmetric, it follows from (25) that the consumer harm share *CHS* is simply:

$$CHS = \frac{\tau Q \mathrm{d}c}{(1+\lambda\tau)Q\mathrm{d}c.} = \frac{1}{1/\tau+\lambda}. \tag{26}$$

Boone and Müller's formula in their proposition 1 reduces to (26) when firms are symmetric. Intuitively, consumers tend to suffer a greater share in total harm (relative to direct purchasers) if the pass-on rate $\tau$ is high and if the direct purchasers' market power $\lambda$ is small.

Han, Schinkel and Tuinstra [2008] consider total harm when there are multiple layers of indirect purchasers between the direct purchasers and the final consumers. It is straightforward to generalize Proposition 5 to incorporate multiple layers in our framework. This gives the same total harm formula (25), where $\lambda$ should be reinterpreted as the overall profit margin of direct and indirect purchasers (adjusted for the elasticity), and $\tau$ as the combined pass-on rate of direct and indirect purchasers.[27,28]

*Policy options*. We can apply this framework to consider two key policy questions in private enforcement of cartel legislation. First, should a passing-on defense against direct purchasers be allowed, and if so, should it be adjusted for the output effect? Second, should final consumers (or other indirect purchasers) have legal standing to obtain compensation? These questions are relevant both from the perspective of *compensation* of the direct purchasers and consumers and from the perspective of *deterrence*, i.e., the liability of the defendants.

Table IV shows the effects on the different parties of the various policy options. For example, the top left cell shows what happens to direct purchasers and final consumers if no passing-on defense is allowed and if final consumers have no legal standing, as is currently the case in several U.S.

[27] To see this, consider two instead of one downstream layers, with common prices at all layers. The cartel charges a price $c$ to the direct downstream layer 1, which charges a price $p^1$ to the second, indirect downstream layer 2, which in turn sells at a price $p^2$ to final consumers. Layer 1 and layer 2's industry profits are, respectively, $\Pi^1(c) = \left(p^1(c) - c\right)Q\left(p^2(p^1(c))\right)$ and $\Pi^2(c) = \left(p^2(p^1(c)) - p^1(c)\right)Q\left(p^2(p^1(c))\right)$. Consumer surplus is $v(p^2(p^1(c)))$. Differentiate total downstream surplus $S(c) = \Pi^1(c) + \Pi^2(c) + v(p^2(p^1(c)))$ with respect $c$ to obtain

$$\frac{dS}{dc} = -\left(1 + \lambda^2\tau^2\tau^1\right)Q,$$

where $\tau^1 = dp^1/dc$ and $\tau^1 = dp^2/dp^1$ are layer 1 and 2's pass-on rates, and $\lambda^2 = \varepsilon(p^2 - c)/p^2$ is the conduct parameter summed over both layers 1 and 2. This generalizes (25), where the pass-on rate is now the product of the pass-on rates of both layers 1 and 2.

[28] The change in total welfare, or deadweight loss, can also be derived. This requires adding the change in the cartel's profits to the total harm d$S$. Let $\tilde{\lambda}$ denote the cartel's competition parameter in the absence of the cartel (the elasticity-adjusted profit margin as a fraction of consumer price $p$). It can be verified that the cartel's profit increase is $(1-\tilde{\lambda})\tau Q\mathrm{d}c$, so the cartel can generally not appropriate all of the price overcharge gains $Q\mathrm{d}c$. Hence, the change in total welfare or deadweight loss equals $-(\lambda+\tilde{\lambda})\tau Q\mathrm{d}c$.

TABLE IV
COMPENSATION AND LIABILITY UNDER ALTERNATIVE POLICY OPTIONS

| passing-on defense? | affected party | final consumers legal standing? no | yes |
|---|---|---|---|
| no | direct purchasers | $Q\mathrm{d}c$ (unjust enrichment) | $Q\mathrm{d}c$ (unjust enrichment) |
| | final consumers | 0 (unjust impoverishment) | $\tau Q\mathrm{d}c$ (correct compensation) |
| | total | $Q\mathrm{d}c$ (underliability) | $(1+\tau)Q\mathrm{d}c$ (overliability) |
| unadjusted (no account for output effect) | direct purchasers | $(1-\tau)Q\mathrm{d}c$ (unjust impoverishment) | $(1-\tau)Q\mathrm{d}c$ (unjust impoverishment) |
| | final consumers | 0 (unjust impoverishment) | $\tau Q\mathrm{d}c$ (correct compensation) |
| | total | $(1-\tau)Q\mathrm{d}c$ (underliability) | $Q\mathrm{d}c$ (underliability) |
| adjusted (account for output effect) | direct purchasers | $(1-(1-\lambda)\tau)Q\mathrm{d}c$ (correct compensation) | $(1-(1-\lambda)\tau)Q\mathrm{d}c$ (correct compensation) |
| | final consumers | 0 (unjust impoverishment) | $\tau Q\mathrm{d}c$ (correct compensation) |
| | total | $(1-(1-\lambda)\tau)Q\mathrm{d}c$ (underliability) | $(1+\lambda\tau)Q\mathrm{d}c$ (correct liability) |

states. The advantage of such a policy is simplicity since it is only necessary to estimate the price overcharge and not to measure the pass-on and output effects. However, there is no correct compensation. The direct purchasers experience 'unjust enrichment': they are compensated proportional to the full overcharge (an amount of $Q\mathrm{d}c$) although they can pass on part of the overcharge (so that the correct compensation would be $(1-(1-\lambda)\tau)Q\mathrm{d}c$). Similarly, the final consumers suffer from 'unjust impoverishment' as they get nothing even though the direct purchasers passed on part of the overcharge. Finally, there is insufficient liability of the defendant, because the total amount to be paid ($Q\mathrm{d}c$) is less than the total harm $(1+\lambda\tau)Q\mathrm{d}c$.

The other cells can be interpreted in a similar way. For each policy option one can verify whether the direct purchaser and final consumers get compensated too much or too little (first and second row of each cell), and whether the defendant pays a total amount that corresponds to the total harm. The general conclusion is that compensation and liability are only correct under an adjusted passing-on defense and with legal standing to final consumers (bottom right cell). The policy maker must therefore trade off economically sound compensation and liability against informational and computational simplicity.

## VIII. CONCLUDING DISCUSSION

We have developed a general economic framework to assess cartel damages to a purchaser plaintiff, starting from the anticompetitive price overcharge (or cost effect) as the commonly used basis. We have identified the circumstances under which an adjusted passing-on defense against the purchaser plaintiff is justified. This defense takes into account that any pass-on of the price

overcharge by the plaintiff may subsequently also lead to a reduction in its output. We note, however, that a proper account of the output effect in the passing-on defense may actually turn against the defendant, when one considers the cartel's total harm (i.e., including the effect on final consumers).

Incorporating the output effect in the passing-on defense raises the informational requirements only moderately. For a wide variety of cases, we obtain formulas to discount the price overcharge that depend on observable variables for the purchaser plaintiff's industry. They naturally lead to two empirical approaches. The first is a reduced-form approach and relates most closely to a traditional pass-on analysis. It entails estimating the appropriate pass-on rate (firm-specific of industry-wide) and then adjusting that pass-on rate based on our derived discount formulas for alternative industries.[29] The second approach is the structural approach. This requires substituting the pass-on rate out of the discount formulas, and then estimating all relevant supply and demand parameters entering the discount formula.[30] We illustrated this second approach with the European vitamin cartel.

Our analysis is particularly timely in light of the recent recommendations of the U.S. Antitrust Modernization Commission and the efforts by the European Commission to stimulate private cartel damages claims. Two key policy questions are whether a passing-on defense against direct purchasers should be allowed and whether final consumers (or other indirect purchasers) should have legal standing to obtain compensation. The policy maker must trade off economically sound compensation of the affected parties and liability of the defendant against informational simplicity. The option of no passing-on defense and no legal standing of final consumers has the advantage of informational simplicity. It enables focusing on estimating the cartel's price overcharge, for which there is extensive experience including econometric estimation, as reviewed in, e.g., van Dijk and Verboven [2008] or Davis and Garces [2007]. However, it implies incorrect compensation of the affected parties and insufficient liability since the output effect is ignored. In contrast, the alternative option of an adjusted passing-on defense and legal standing of final consumers is more in line with correct compensation and liability. Our analysis suggests that the informational requirements for this alternative option are not insurmountable.

[29] The empirical literature on estimating pass-on rates is very large, and relates to various areas, including the literature on exchange rate pass-through literature, on tax incidence, on price transmission in agricultural economics, and on market power and competition. See Stennek and Verboven [2001] for an overview. A paper of particular interest in our context is by Ashenfelter, Ashmore, Baker and McKerman [1998], showing how to estimate empirically the firm-specific pass-through rate (in the context of evaluating efficiency gains from mergers).

[30] For example, Proposition 4 writes the Bertrand discount (14) in terms of pass-on rates but our subsequent logit example in section 5.1 eliminates the pass-on rate and writes the discount formulas in terms of demand parameters and market shares. Conversely, Proposition 5 writes the Cournot discount formula (24) in terms of a demand curvature parameter and market variables, but we subsequently rewrite it in terms of the pass-on rate and market variables.

APPENDIX

## AI. *The Logit Model*

The potential number of consumers is $L$. Each consumer may buy one of the $N$ differentiated products or the outside good. The demand for product $i = 1 \ldots N$ is $D_i(\mathbf{p}) = s_i(\mathbf{p})L$, where $s_i = s_i(\mathbf{p})$ are the market shares given by

$$s_i(\mathbf{p}) = \frac{\exp(v_i - \alpha p_i)}{1 + \sum_{k=1}^{N} \exp(v_k - \alpha p_k)}.$$

The market share of the outside good 0 is simply $s_0(\mathbf{p}) = 1 - \sum_{i=1}^{N} s_i(\mathbf{p})$, so that the demand for the outside good is $D_0(\mathbf{p}) = s_0(\mathbf{p})L$. The market share derivatives are

$$\begin{aligned} \frac{\partial s_i(\mathbf{p})}{\partial p_i} &= \alpha s_i(1 - s_i) \\ \frac{\partial s_k(\mathbf{p})}{\partial p_i} &= \alpha s_i s_k \qquad \text{for } k \neq i. \end{aligned}$$

Using the diversion ratio between firm 1 and firm $k$,

$$\delta_1^k = -\frac{\partial D_k(\mathbf{p})}{\partial p_1} \bigg/ \frac{\partial D_1(\mathbf{p})}{\partial p_1} = \frac{s_k}{(1 - s_1)},$$

we can apply (14) to write the discount to the overcharge as:

$$\text{discount} = \frac{s_2}{(1 - s_1)} \tau_I^2 + \cdots + \frac{s_i}{(1 - s_1)} \tau_I^N. \tag{27}$$

If the pass-on rates are known or estimated, this can be used to calculate the discount. Alternatively, the pass-on rates can be computed by performing comparative statics on the system of first-order conditions defining the Bertrand-Nash equilibrium:

$$p_i - c_i - \frac{1}{\alpha} \frac{1}{1 - s_i} = 0 \quad \text{for all } i.$$

To perform the comparative statics of a cost increase by firm $i$ on prices, totally differentiate this system with respect to $p_k$, $k = 1 \ldots N$, and $c_i$. The tedious calculations are somewhat similar to Anderson, de Palma and Thisse [1992], pp. 266–267, except that the comparative statics are in cost rather than in quality and that an outside good is included. This results in the following pass-on rates

$$\begin{aligned} \tau_i^i &= \frac{\partial p_i^*(\mathbf{c})}{\partial c_i} = \frac{s_i}{(1-s_i)^2 + s_i} T_i + \frac{(1-s_i)^2}{(1-s_i)^2 + s_i} \\ \tau_i^k &= \frac{\partial p_k^*(\mathbf{c})}{\partial c_i} = \frac{s_k}{(1-s_k)^2 + s_k} T_i \qquad \text{for } k \neq i. \end{aligned}$$

where

$$T_i = \frac{s_i(1 - s_i)^2}{(1 - s_i)^2 + s_i} \bigg/ \left( s_0 + \sum_{k=1}^{N} \frac{s_k(1 - s_k)^2}{(1 - s_k)^2 + s_k} \right).$$

Note that $T_i = \sum_{k=1}^{N} s_k \frac{\partial p_k^*(\mathbf{c})}{\partial c_i}$, i.e., $T_i$ can be interpreted as the effect of a cost increase of firm $i$ on the industry price index, using market shares as weights. Inserting the pass-on effects in $\tau_I^k$, $k = 2 \ldots N$ and then in (27), and rearranging gives the following expression

for the discount

$$\text{discount} = \frac{\left(\sum_{i \in I} T_i\right) - s_1(1 - s_1)}{(1 - s_1)^2 + s_1}.$$

This can be computed based on information on the market shares of all products including the outside good.

## AII. *Proof of Proposition 4*

The assumptions of the Cournot model involve the following inequalities: (i) $\rho s_1 \leqslant 1$, (ii) $\rho \leqslant N$, (iii) $N > 1$ and (iv) $0 < s_1 < 1$. To show the proposition, we have to derive the sign of the discount (24) or equivalently the sign of $2N_I - N - 1 - \rho(s_1 N_I - 1)$ under (a) $N_I = N$ and (b) $N_I = 1$.

To show (a), we have to show that $N - 1 - \rho(s_1 N - 1) > 0$. Consider all possible cases for $\rho$. First, if $\rho > 1$, then $N - 1 - \rho s_1 N + \rho \geqslant N - 1 - N + \rho = \rho - 1 > 0$ by (i). Second, if $0 \leqslant \rho \leqslant 1$ and $s_1 N - 1 \geqslant 0$, then $N - 1 - \rho(s_1 N - 1) \geqslant N - 1 - (s_1 N - 1) = N(1 - s_1) > 0$ by (iv). Third, if $0 \leqslant \rho \leqslant 1$ and $s_1 N - 1 < 0$, then $N - 1 - \rho(s_1 N - 1) \geqslant N - 1 > 0$ by (iii). Fourth, if $\rho < 0$ and $s_1 N - 1 \geqslant 0$, then $N - 1 - \rho(s_1 N - 1) \geqslant N - 1 > 0$ by (iii). Fifth, if $-(N - 1) \leqslant \rho < 0$ and $s_1 N - 1 < 0$, then $N - 1 - \rho(s_1 N - 1) \geqslant N - 1 + (N - 1)(s_1 N - 1) = (N - 1)s_1 N > 0$ by (iii). Finally, if $\rho < -(N - 1)$ and $s_1 N - 1 < 0$, then $N - 1 - \rho(s_1 N - 1) > 0$ is equivalent with the market share condition $s_1 > \frac{1}{N} - \frac{N-1}{N}\frac{1}{(-\rho)}$. This shows that the discount is always positive, unless possibly in the final case, namely. if $\rho < -(N - 1)$ and $s_1 < \frac{1}{N} - \frac{N-1}{N}\frac{1}{(-\rho)}$.

To show (b), we have to show that $1 - N + \rho(1 - s_1) < 0$. Consider again all possible cases for $\rho$. First, if $\rho \leqslant 0$, then $1 - N + \rho(1 - s_1) \leqslant 1 - N < 0$ by (iii). Second, if $0 < \rho \leqslant 1$, then $1 - N + \rho(1 - s_1) < 1 - N + \rho \leqslant 1 - N + 1 \leqslant 0$ by (iii). Third, if $\rho > 1$ and $s_1 N - 1 \geqslant 0$, then $1 - N + \rho(1 - s_1) < 1 - N + N(1 - s_1) = 1 - s_1 N \leqslant 0$ by (ii). Fourth, if $N - 1 > \rho > 1$ and $s_1 N - 1 < 0$, then $1 - N + \rho(1 - s_1) < 1 - N + (N - 1)(1 - s_1) = -(N - 1)s_1 < 0$ by (iii). Finally, if $\rho > (N - 1)$ and $s_1 N - 1 < 0$, then $1 - N + \rho(1 - s_1) < 0$ is equivalent to the market share condition $s_1 > \frac{1}{N} - \frac{N-1}{N}\frac{N-\rho}{\rho}$. This shows that the discount is always negative unless possibly in the final case, namely if $\rho > (N - 1)$ and $s_1 < \frac{1}{N} - \frac{N-1}{N}\frac{N-\rho}{\rho}$.

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